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JOURNAL

OF THE

AMERICAN WELDING SOCIETY

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American Welding Society

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JUL 29 1922

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Volume 1 July, 1922 Number 7

TABLE OF CONTENTS

Society and Related Activities

Page

Report of Membership Committee 3
Advertising 4
Research Activities 4
Section News 5
New Members 6
Employment Service 8

Technical Papers, Items and Reports

Electric Arc Welding in Locomotive Work 9
Managerial Understanding of Welding 20
Matching Wire with the Work 22
Resistance Welding Nomenclature 24
Review of Electro-Percussive Welding 27
Current Welding Literature 36

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AMERICAN WELDING SOCIETY

ESTABLISHED 1919

JOURNAL

VOL. 1 JULY, 1922 NO. 7

REPORT OF MEMBERSHIP COMMITTEE AS SUBMITTED APRIL 27, 1922

Notwithstanding the fact of an exceedingly dull business year, the Membership Committee reports progress. At the annual meeting of 1921 the total membership of the Society numbered 574 members, divided into classes as follows:

A	81
B	193
C	45
D	254
E	1

At the annual meeting in 1921, six sections were operating with a membership as follows:—

Philadelphia	165
Chicago	25
Pittsburgh	64
New York	164
Northern New York	40
Cleveland	15
Not in Sections	101
Total	574

At the annual meeting in 1922 seven sections were operating, with a membership as follows:

Philadelphia	113
Chicago	57
Pittsburgh	56
Cleveland	42
New York	147
Northern New York	79
San Francisco	21
Not in Sections	80
Total	595

Increases from April 30, 1921, to April 24, 1922:

A	1
B	56
C	40
D	113
	210

Resignations and those dropped for delinquency for period from April 30, 1921, to April 24, 1922—189. Total membership on April 24, 1922—595.

It is interesting to note that at the present time, July 1, 1922, the present membership totals 649, which is sub-divided into sections as follows:

Chicago	64
Cleveland	40
New York	153
Northern New York	79
Philadelphia	115
Pittsburgh	58
San Francisco	39
Los Angeles	17
Boston	12
Not in Sections	72
Total	649

It is also interesting to note that, although 189 members resigned or were dropped during the year 1921-22, that the increase of membership in a period of great industrial depression more than compensated for this amount, and that our present membership, 649, is larger than it was at any time during the history of the American Welding Society; for example, membership April 30, 1921, was 574, and April 24, 1922, was 595. Sections are being established in the following cities:

Atlanta
Denver
Portland
Seattle
Salt Lake City
St. Louis
Cincinnati

We also have been able to induce some of the Class D members who are worthy of higher membership to increase their membership to Class C

and in some cases to Class B, and the feeling of the Committee is that from now on with better business conditions the rate of growth will be materially larger than that of the past year.

A WORD ABOUT OUR ADVERTISERS

In soliciting the advertising for our Journal we have justly maintained that the value of such advertising is mutual to the advertiser and member. Our advertisers include some of the most progressive firms in the welding field. It is only fair to call attention to the support that is being tendered by them in the publication of our Journal.

RESEARCH ACTIVITIES

HOW THE FINISHED PRODUCT EMERGES

Very few of our members realize the amount of work necessary before a finished bulletin of the American Bureau of Welding emerges in printed form.

A session with one of our research committees will therefore be enlightening. Take, for example, the recent meeting of the Committee on the Training of Operators. A number of preliminary meetings were necessary before the individual members came to an agreement as to the objective to be accomplished, what work was necessary and the methods of procedure. However, after several of these sessions, the committee finally agreed to draw up a course on the Training of Operators, which would embody the following points:

I—Qualification for welders, including
  1—Suggestions on the selection of applicants for training.
  2—Suggestions on the testing of welders.

II—Fundamentals of welding.

III—Analysis of welding jobs, including
  1—Oxy-acetylene welding.
  2—Electric arc welding.

IV—Bibliography of welding.

After a discussion of each of these items it was generally agreed that the courses on electric arc welding and gas welding should be kept separate. It is safe to say that every member of the committee has his own idea as to how the work should be done, even though each was considered an expert in his own line. All of these people are busy men. Their time is decidedly limited and is given to the work of the committee without any hope of remuneration. The Federal Board of Vocational Education, which is in charge of this particular problem, is spending its money in sending their representative to these meetings and to the plants and offices of the individual members.

The difficulties encountered in drawing up a course for the Training of Welding Operators can be seen from the following questions:

1—What should be included in the course?

2—How should it be started?

3—For whom is it to be drawn up?

4—How can it be made to fit in with the training schools of the railroad, shipyard, factories, night school, etc.? (Each school has its own methods. Some of them are able to supplement exercise work with production work. Some of them are only interested in a particular type of work, such as, for example, the welding of a particular production job.)

5—What arrangements of jobs should be made in order that the student may be given tasks, each one a little more difficult than the other?

6—What supplementary information is needed, such as mathematics, chemistry, ability to read blue prints?

7—What precautions and safety instructions must accompany the lectures?

8—How can you tell whether a man is going to make a good welder be-

fore time and money is spent on his training?

These are only a few of the questions that must be answered and solved by the committee during the process of drawing up this course of Training of Operators. Very often we are accused of lack of progress, but this is because one is not acquainted with the difficulties of the work involved. Work on a number of bulletins is advancing and before long we expect to have a sufficient number that will reflect credit to both the individual members of the research committees and the Society as a whole. Three bulletins have already been completed.

SECTION NEWS

ORGANIZATION MEETING OF BOSTON SECTION

A preliminary organization meeting of the Boston section was held on May 24 at the Boston City Club. Mr. P. F. McDonald, who acted as chairman, briefly summarized the objects of the American Welding Society and outlined the reason for the formation of the Boston Chapter. The following officers were elected:

Mr. T. A. Wry, chairman, General Electric Co., Lynn, Mass.

Mr. J. J. Flaherty, first vice-chairman, Boston Elevated Railway Co.

Mr. R. C. Waring, second vice-chairman, Eastern Massachusetts Street Railway Co.

Mr. R. L. Browne, treasurer, Metal & Thermit Corp.

Mr. J. W. Morrissey, P. F. McDonald & Co., secretary.

A second meeting was held on June 23 at the Boston City Club to complete the organization of the section. A number of people interested in welding living in Boston and vicinity were invited to this meeting. Mr. C. A. McCune, president of the American Welding Society, outlined the organizational scheme of the Society. He stated that sections of the Welding Society are now organized in several large cities, others will be formed in the various industrial centers throughout the country to assist in promoting the work of the Society. Regular monthly meetings are held in each section, at which papers and lectures of general interest are presented. Means are thus established for mutual co-operation, assistance and advancement. He further outlined the work of the Society—its research department, the American Bureau of Welding and the prominence it has attained in the welding industry. He was followed by Professor C. A. Adams, the founder of the Society and its first president, who spoke on the history of research by the Society and emphasized the importance of the co-operative movement in research in the welding field. Professor Elihu Thomson, first honorary member of the Society, spoke on the early developments of welding and predicted that eventually all permanent metal joints will be made by welding. The remarks made by these speakers were supplemented by Mr. C. J. Holslag of the Electric Arc Cutting and Welding Co. and Mr. W. A. Slack of the Torchweld Equipment Co. Those present at the meeting were:

Officers

Mr. T. A. Wry, General Electric Co., Lynn, Mass., chairman.

Mr. J. J. Flaherty, Boston Elevated Railway Co., first vice-chairman.

Mr. R. L. Browne, Metal & Thermit Corp., treasurer.

Mr. J. W. Morrissey, P. F. McDonald & Co., secretary.

Guests

C. A. McCune, national president

Professor Elihu Thomson, first honorary member, consulting engineer, General Electric Co.

Professor C. A. Adams, second hon-

orary member, director of American Bureau of Welding

Mr. W. A. Slack, vice-chairman, A. W. S., Chicago Section

Mr. C. J. Holslag, Electric Arc Cutting & Welding Co.

Members

Messrs. P. F. McDonald, M. J. McDonald, N. L. Schuver, Malcolm Thomson, P. Alexander, H. A. Woofter, Hill, H. O. Westendarp, R. G. Anderson, Dr. A. Krebs, C. Lee, H. D. Large, F. J. Giduz, C. D. W. Gibson, Hunter, Webb, H. F. Russen, A. C. Hagerty, B. W. Horsman, C. L. McLean, J. A. Mooney, J. R. Robinson, Alfred Oleson, Wheelock.

MAY MEETING SAN FRANCISCO SECTION

At the May meeting of the San Francisco Section a report was presented by the Committee on the Welding of Pressure Vessels, which was forwarded to the parent organization for their approval. A paper was presented by Mr. R. S. Fuller, Engineer of Distribution, Pacific Gas and Electric Company, on the Welding of Gas Mains. This paper brought out a very interesting discussion.

JUNE MEETING PHILADELPHIA SECTION

A meeting was held by the Philadelphia Section on June 19, at which time Mr. G. O. Carter, Consulting Engineer of the Linde Air Products Company, presented a paper on "Importance of Managerial Understanding of Welding."

The next meeting of the Section will be held on September 18, at which time Professor A. S. Kinsey, Advisory Service Engineer of the Air Reduction Sales Company, will show some films and give a lecture on the manufacture of Oxy-Acetylene.

NEW MEMBERS FOR MONTHS OF APRIL, MAY AND JUNE

CHICAGO	*Class*
Walter Beach, Acetylene and Electric Welder	D
F. L. Danczyk, Welder, Western Electric Co.	D
M. A. Dantzler, Sales Engineer, Gas Tank Recharging Co.	A
S. Gavil, Acetylene Welder, Acheson Topeka & Sante Fe R. R.	D
G. L. Gunther, Gas and Electric Welder	D
F. J. Hrunek, Welder, Western Electric Co.	D
J. L. Kinsock, Foreman, Standard Oil Co.	C
W. R. Kremer, General Sales Manager, Vilter Mfg. Co.	C
J. W. LeGrande, Welder, Western Electric Co.	D
John Nolan, Acetylene Welder	D
W. A. Owens, Electric Welder	C
H. B. Pearson, Vice-President, Burdett Oxygen Co.	B
G. F. Schmid, Sales Manager, Central Dept., Oxweld Acetylene Co.	B
E. L. Swangren, Foreman Welder, Western Electric Co.	C

LOS ANGELES	*Class*
H. P. Bancroft, Welding Foreman, P. E. Railway	D
A. H. Bartlett, S. P. R. R. Shop Electrician	D
H. J. Barton, Jamison Steel Co.	C
A. D. Callahan, Electric Welder	D
C. J. Coberly, Engineer, California Compressed Gas Co.	B
E. W. Crane, E. E., Wilson Welder & Metal Co.	C
J. H. Cunningham, Sales Agent, General Electric Co.	C
A. E. DeBurn, Welder Foreman, Gay Engineering Corp.	C
J. B. Eastman, Proprietor, Welding Shop	B
B. H. Eaton, Engineer, Way and Structures, Los Angeles Railway Corp.	B
A. B. Fidler, Welder, P. E. Railway	D
J. E. Granger, Electrician	D

G. W. Lyons, Electric Welder ... D
G. H. Miller, Electric Welder, S. P. Co. Shops ..... D
R. B. Rawls, Sales Agent, U. S. Steel Products Co. C
W. H. Sweet, Sales Engineer, Westinghouse Electric & Mfg. Co. C

NEW YORK *Class*

H. V. Gigandet, District Manager, Oxweld R. R. Service Co. ..... B
H. A. Kimball, Electric Welder .. D
J. W. O'Neill, District Superintendent, Oxweld R. R. Service Co. ..... B
John Rich, Roadmaster, Third Av. Ry. Co. C
M. A. Thompson, Instructor, Oxweld R. R. Service Co. ..... D
John Tobin, Roadmaster, Union Div., Third Av. Ry. Co. C
Curtis Voigtlander, M. E., George C. Moon Co. ..... B
Watson Williams, District Superintendent, Oxweld R. R. Service Co. ..... B

NORTHERN NEW YORK *Class*

John Berent, Manager, Lockport Boiler and Welding Works ... C

PITTSBURGH *Class*

L. R. Hoffman, Machinist ..... D
G. P. Stewart, Garage Manager, Stewart Garage ..... D

SAN FRANCISCO *Class*

J. H. Bedell, Superintendent, Tract. No. 3, Avon Refinery, Associated Oil Co. ..... D
J. C. Bennett, Assistant Engineer, Associated Oil Co. ..... A
G. M. Brittain, Foreman, Brown Bros. Welding Co. ..... D
W. J. Cain, Electric Welder ..... D
H. D. Coleman, Garage Foreman, Amalgamated Oil Co. ..... D
S. D. Denine, Electric Arc Welder D
T. A. Errett, Manager, National Welding Equipment Co. C
Marcell Ferro, Electric Welder Bethlehem S. B. Corp. ..... D
L. E. Foust, Acting Superintendent, Kern Div., Associated Oil Co. ..... D
W. A. Greer, Superintendent, Coalinga Div., Associated Oil Co. ..... D
E. O. Johnstone, District Sales Manager, Page Steel & Wire Co. B
Chas. Larzelere, Welder, N. W. P. R. R. Co. ..... D
H. A. Patterson, Welder Foreman, A. T. & S. F. Railway Shops ..... D
F. P. Pinkham, Oxy-acetylene Welder, Pacific Pipe Co. ..... D
M. Rhine, Special Solicitor, General Electric Co. C
R. S. Risdon, Welder, San Francisco Brazing & Welding Works C
H. Rose, M. M. Avon Refinery, Associated Oil Co. ..... D
C. M. Small, Superintendent, Midway Div., Associated Oil Co. ... D
G. C. Thorpe, Superintendent, Santa Maria Pipe Lines, Associated Oil Co. C
Herman Ullmer, Service Engineer, Linde Air Products Co... B
G. O. Wilson, Engineer, Standard Oil Co. ..... B
Cecil Wright, Electric Welder, Bethlehem S. B. Corp. ..... D

(NOT IN SECTIONS)

R. J. Johnstone, N. M. United Comstock Mines Co., Nevada .. C
E. F. Harris, Foreman of Machine Shop, Mexico C
David Hastings, Superintendent, Machine and Boiler Shops, The Goldie & McCulloch Co., Ontario C
H. C. Price, Manager, Electra Welding Co. ..... B
Richard Secor, Welding Dept., Foreman, Industrial Works ... D
Frank D. Speiser, Elec. Welder, United Comstock Mines, Nevada ..... D

EMPLOYMENT SERVICE BULLETIN

To meet the demand of its members, the American Welding Society maintains an Employment Service Bulletin. This service is particularly needed in the present business readjustment. The bulletin is divided into two sections —POSITIONS VACANT and SERVICES AVAILABLE. No charge will be made either to the available engineer, foreman or welder, or to the organization seeking welding talent. The number of opportunities for employment of which the Society has knowledge does not at present equal the number of men whose services are available. The co-operation of members of the Society, industrial establishments and others needing the services of men trained in the various branches of welding is earnestly desired. The fact that an applicant for a particular position reads the Journal of the American Welding Society shows an honest effort on his part to keep abreast of the latest advancements in his chosen field. The location, necessary qualifications for each position and the approximate salary, if possible, should be stated in each case.

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the bulletin.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Announcements will not be repeated except upon request received after an interval of three months; during this period names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's office not later than the Thirtieth of the month if publication in the following issue is desired. All replies should be addressed to the number indicated in each case and mailed to Society Headquarters.

POSITIONS OPEN

V-5—Wanted. Two first-class electric welders for work in Baton Rouge, La. Transportation will be paid from any point in the South to Baton Rouge, but no return transportation. Work guaranteed for at least thirty days at 94c. per hour.

V-6—Wanted. A man with considerable practical experience in oxy-acetylene and electric welding, particularly oxy-acetylene, and who is of the caliber to make a high-class foreman. We would like to have some one who knows something of the theoretical side of welding.

USE AND ABUSE IN ELECTRIC ARC WELDING IN LOCOMOTIVE WORK*

C. W. ROBERTS†

Electric arc welding, as we all know, is of comparatively recent origin, and as we believe in the American Welding Society is just in its infancy. As in everything else, we no sooner discover or perfect a new method, but what it is immediately subjected to abuse.

Electric arc welding is now indispensable in a large number of our industries and will continue to increase in importance and efficiency. It will increase more rapidly if we all strive to eliminate the abuse that is brought about by carelessness, ignorance of limitations, and lack of interest.

There is considerable discussion and differences of opinions as to just what should or should not be welded. It is undoubtedly true that in all processes of autogenous welding that an intense local heating is unavoidable and that in the cooling there is liable to be a certain amount of locked up stresses in some jobs.

Now the question I would like to have answered is: are these locked up stresses great enough and so menacing as to warrant the discontinuance of a large amount of our welding?

It is undoubtedly true that different locomotive parts that have been electrically welded have since failed, some after long and very hard service. Similar parts that have never been welded have failed also. I refer to such parts as crossheads, pistons, rocker arms, valve yokes, guides, link motion parts and similar machinery.

Let us investigate these failures thoroughly and without prejudice or partiality, and find out if the failure was caused from locked up stresses, fatigued metals, faulty or inferior castings and forgings, or by the inefficient and careless welder or supervisor.

In electric arc welding, as in everything else, there are limitations, and an efficient supervisor will know these limitations and will refuse to go beyond them, as he knows such work only leads to the condemning of the entire practice of electric arc welding. It therefore, follows that to have efficient supervision your supervisor must have co-operation.

The greatest causes of failures are the inefficient and indifferent workmen and the little heed taken to have a perfectly clean and properly prepared job; although suitable equipment and proper electrodes for the work at hand should not be overlooked. Your finished result, I might say, is 90 per cent operator, 10 per cent equipment and materials, while preparation and operation are about a 50-50 break. You cannot get thoroughly satisfactory results no matter how good your welder's ability may be, if the work is not first properly prepared.

Our men on this work with which I am most familiar are weld-

*Presented at the April, 1922, meeting of Pittsburgh Section, A. W. S.

† Welding foreman, Pennsylvania Railroad, Columbus, Ohio.

ers; they are able and do do all kinds of autogenous welding. They are men who started at the bottom and were retained because of their ability and interest in welding. They have become proficient in all phases of electric arc welding and oxy-acetylene welding. They are welding operators, which is and should be recognized as a trade in itself; a trade in which a man should receive instructions and serve an apprenticeship, just as a boilermaker, blacksmith, machinist or any other craftsman. Just because a man is any one of these craftsmen, is far from being an intelligent or rational reason why that man should be called a welder, given the welder's rate of pay and set to work. This is one of the chief reasons why to-day we have so much inferior work for which electric arc welding is being condemned. It should be the incapable operator and not the method that should be condemned.

Your craftsman may become a welder operator after he has received instructions and served his apprenticeship (if he has the ability), and he may be able to master all phases of electric arc welding and oxy-acetylene welding, such as firebox, boiler, machinery and equipment work, in the round house, back shop, yard or road. However, he will not acquire that ability in its entirety in six (6) days, six (6) weeks, or six (6) months. It takes perserverance, endeavor, and actual experience, and lots of it, to make a thoroughly reliable welder operator. They are not made over night.

We employ both the carbon and metallic arc process and find very large and ever increasing field for both methods. The figures will give a slight idea of a few of our different operations.

Figure (No. 1) shows a cross section of a crosshead guide which was built up so as to finish $\frac{3}{8}$ of an inch higher than the worn sur-

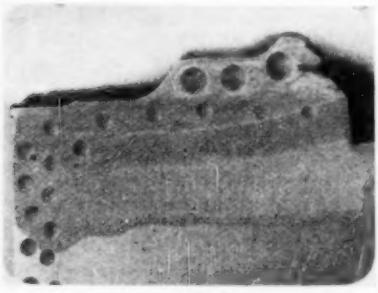

Fig. 1

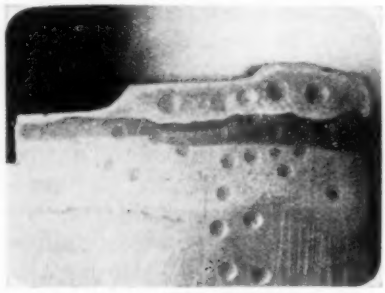

Fig. 2

face. This was done by making two runs of metal with the carbon arc. You will note the very uniform change of structure and heat penetration caused by the two runs of the arc in the original metal adjacent to the weld.

The scleroscopic test for hardness showed the welded metal to be much softer than the original steel which has a carbon content of about .55, while the filler rod conformed to the American Welding Society's specifications and contained .18 carbon. I have been

Fig. 3

pretty well convinced by these and other tests that an electrode should be used in most cases with a chemical analysis that will give you in the weld metal an analysis similar to that of the original metal.

Fig. (No. 2) shows a similar cross section as the previous slide. This was welded by the metallic arc process. Note the uneven line of penetration and the more pronounced and varied change in structure of the original steel. I might add for the information of those unfamiliar with the two methods that the cost of labor per inch is less than four (4) mills in the case of the carbon arc as against eighteen (18) mills in the metallic arc, or your metallic arc in this case costs four and one-half ($4\frac{1}{2}$) times as much as the carbon. If only one-fourth ($\frac{1}{4}$) of an inch of finished metal is desired the difference will be only about 3 to 1.

With the carbon arc we use a $\frac{5}{8}$ in. rod and in the metallic arc a 3/16 in. or $\frac{1}{4}$ in. rod.

Fig. (No. 3) shows how easily electric arc welding can be and is condemned. It shows a crosshead that came into our round house after its run. You can see just what I found. You will notice that in the repairing of this job that the fracture was not followed to its end, but had been "Veed" out and welded where no fracture existed. About six (6) months later I traced this case down and found that an engine house foreman had ordered the crack partly Veed out, welded up and sent out. It got as far as the first inspection point after it left the point where the repairs were made. I then took the acetylene cutting torch and cut out a piece of one (1) inch wide each side of the weld. Fig. (No. 4) will show you what I found. You will note that the fracture had been Veed out just 1/3 the thickness of the casting, welded over and sent out. It is simply suicide to put out such work, you must Vee out the crack entirely and clear through. If your original casting broke in service what do you expect out of a repair such as this? The original casting at this point when cut with the acetylene showed a very porous and badly oxidized metal. Even had the original crack been Veed out properly

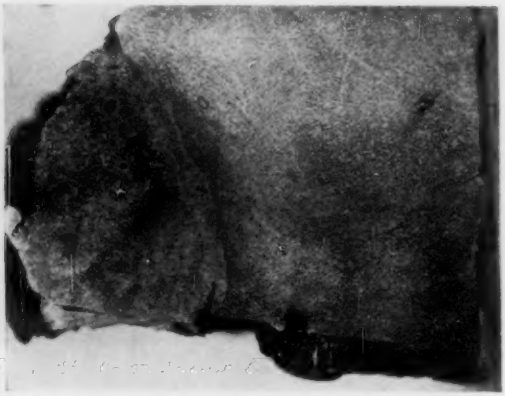

Fig. 4

and welded carefully it would have failed as you will note a small crack which extended from the inside, where it would not have been found. Here then would have been an opportunity to condemn electric arc welding and failure might be attributed to locked up stresses. I might add that this crosshead had seen considerable service as the crosshead pin hole had been filled in by the metallic arc process and rebored and this is never done until after numerous machining has increased the diameter of the hole to the limit.

Fig (No. 5) shows the same crosshead after being welded by the carbon arc process.

During the war when supplies were scarce, most any material that could be obtained was used in electric arc welding and I believe from the appearance of some of our work to-day, this condition is still permitted to exist at some places. This should not be tolerated for proper and suitable electrodes and materials go a long ways toward producing satisfactory results.

Fig. (No. 6) shows the truth of this statement in the matter of suitable electrodes for carbon arc welding. Electrodes one and two are $\frac{5}{8}$ in. in diameter; both were placed in the holder jaw to extend through four inches; both were used constantly for 20 minutes under same voltage, amperage, and other conditions. No. 1 is a carbon and No. 2 a graphite electrode. The carbon decreased in length $1\frac{7}{8}$ in. and in diameter to $\frac{1}{4}$ in. and burnt off the holder jaw as you will note, while No. 2, which is graphite decreased in length $1\frac{1}{8}$ in. with a gradual taper and the holder jaw was not affected in the least. No. 3 is a $\frac{3}{4}$ carbon, somewhat denser than No. 1 carbon. This lasted just 15 minutes (under same conditions as Nos. 1 and 2), when it dropped through the holder jaw having decreased $\frac{1}{2}$ in. in length, also in diameter and burned out the jaws as you will note. A graphite electrode will carry your current in a straight even flowing arc with practically no whipping or spluttering of the flame, while a carbon electrode is unstable, will whip and twist and give

a constant spluttering and squealing arc. Graphite electrodes keeps your welder operators amiable and contented and pays big dividends in the amount of work accomplished and the amount of electrodes and holder jaws saved to say nothing of the superior quality and even flow of metal.

Fig. 5

We will now pass on to the metallic arc process as we use it in firebox work. Every welder operator considers himself your best welder, but an efficient supervisor knows his men and uses them according to their ability. When so much depends on a sound and thorough weld as in firebox work, employ only your highest trained men, men that have proven themselves by the actual result of their test stubs and whose ability is known beyond a doubt. Here perhaps

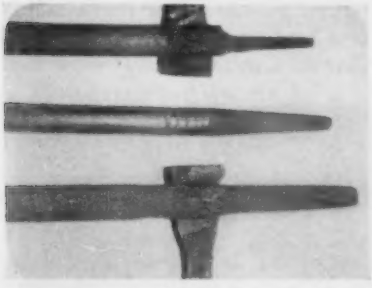

Fig. 6

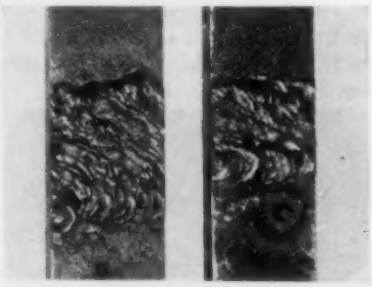

Fig. 7

more forcibly than in any other work, except flues, comes up the question of proper preparation before welding.

Fig. (No. 7) gives a view of the fire side of two (2) firebox side sheet seam welds, both beveled to a 45 deg. angle, one with a $\frac{1}{8}$ in. the other with a $\frac{3}{8}$ in. opening between the two sheets. Both appear on the face or outward appearance to be very successful welds. But electric arc welds like men are not always what they appear outwardly. Note the uniformity of the welded metal in these two (2) specimens.

Fig. 8

Fig. 9

The result obtained in the two specimens can be seen from Fig. No. 8 which is a cross section view of these same specimens. Notice how the metal from the electrode is forced through the 1/8 in. opening and how it forms both corners of the "V" into a seam resembling a rivet head, also note the small amount of metal that is required to fill the "V" and properly finish the seam. This is the ideal prepared seam as it requires a minimum amount of electrode or added metal, and a minimum amount of heat which is of great importance in all firebox work. While the 3/8 in. opening as you see requires an excessive amount of welded material, and therefore, excessive heat. In the 3/8 in. opening or even 1/4 in. opening you cannot unite the two sheets with one run of your electrode as in the 1/8 in. opening, but must first make two or more runs on your lower sheet in order to make the opening small enough to unite the two sheets. The side and door sheets being of from 5/16 in. to 1/2 in. steel gives you a very narrow surface on which to build up, with the result that your inside corner is melted off and your metal after the first run will be very hard to control and as you are not able to see the back side, you get results similar to the above.

Fig. 10

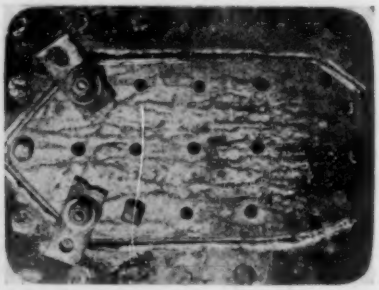

Fig. 11

Fig. (No. 9) is an enlarged view of electrically welded side sheet seams with 45 deg. bevel and a 1/8 in. opening. Note the rivet head effect of the seam and the line of heat penetration or change in structure of the parent metal.

Fig. (No. 10) is a 3/4 side sheet the seam of which is being elec-

trically welded. You can readily see the process of the two runs of the electrode, which completely finishes the seam. With a 45 deg. bevel in the two (2) sheets with a 1/8 in. opening, the welder is able to completely unite the two sheets and fill in about one-half of the "V" with the first run of the electrode. Care must be taken not to proceed too rapidly so as to avoid an excessive amount of heat in the two sheets. Proceed slowly and weld thoroughly with your first run and you will never have one of these seams crack for you. The iron oxide (that has formed) should be completely brushed away with a wire hand brush, using a hand hammer and chisel to remove any slag that has been formed on the edge of the "V." The second run of the electrode should completely fill the remainder of the "V" reinforcing the weld about 1/16 of an inch and extending beyond the two edges of the "V" about 1/8 in.

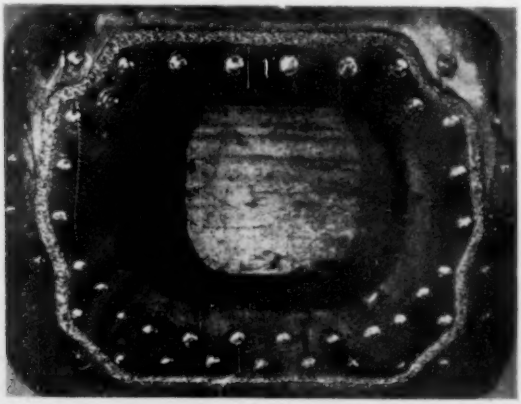

Fig. 12

Prepare your seams in a straight line, but in door collars and all patches, studiously avoid square corners. Fig. (No. 11) illustrates a side sheet patch. Fig. (No. 12) shows the practice in welding in a door hole collar.

No electric arc weld is as strong as the original sheet for the simple reason that the metal deposited through the arc is necessarily a cast metal, while your sheets are forged or rolled steel. Therefore, the more thorough your preparation of the sheets and the less welded material in your seams, the stronger your finished job. Use a 1/8 or 5/32 electrode, with the chemical properties about as follows:

Carbon not over	0.18
Maganese	0.64
Sulphur and phosphorus	0.05

Electric arc welding gives a stronger seam than riveting and there is never any future work necessary, such as caulking. Your riveted seams give about 60 per cent of the strength of the origi-

nal steel, while I have gotten as much as 96 per cent in an electric arc weld.

I have a test report here that I want to give you just to show what results are possible in metallic electrode welding. These tests coupons were welded under the same conditions as I have described in the firebox, seam welded and are the results obtained by three of my welders.

Specimen	Elongation in 2 in.	Load Pounds per sq. inch	Efficiency
1	6.5%	42,700	
2	8.5%	52,800	
3	5.0%	47,600	
Avg. (above)	6.7%	47,700	86.7%
Avg. (3 others)	7.0%	51,400	93.5%
4	8.0%	51,900	
5	8.0%	53,300	
6	7.0%	51,400	
Avg. (above)	7.7%	52,200	94.6%

The original tensile strength was 55,000 per square inch.

These coupons were ½ in. boiler steel which were shaped smooth before testing, leaving no welding reinforcement.

These tests were made at the Ohio State University by Professor D. J. Demerest, Professor of Mines and Metallurgy.

Now the next question in your mind, no doubt, is what is the cost in comparison with a riveted seam. I will say in so far as I have investigated, that to rivet in these seams (labor and material) it will run from 90c to $1.25 per lineal foot, while with the metallic electrode these seams, electric energy at 3c per k. w. hour (140 amperes at 92 volts or 22 volts across the arc), will cost per foot, .09c, 5/32 electrodes at 7.5c per lb; per foot, .05c, 25 min. time for welder operator (a) 50c per hour; per foot, .21c, making the entire cost per lineal foot 35 cents.

Fig. 13

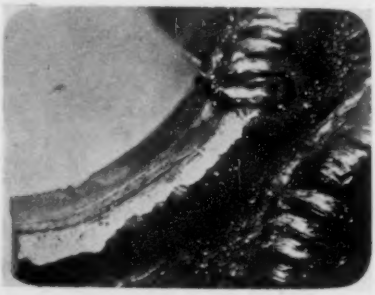

Fig. 14

The question of proper procedure and method of flue welding is an open one and perhaps some of you may differ with me on the subject. I am not prepared to say that the method we pursue is

best, but am simply going to give you a few facts as I have found them.

First, last and always, I am talking and insisting on proper preparation before welding any job, and in flue welding cleanliness and proper preparation are the first considerations. If your flue sheet is a new one, sand blasting thoroughly will give you a clean sheet, if an old sheet and one that has been welded before, the previous weld must be chipped clean from the sheet. Place your copper ferrules so that after rolling them in place they will set back from the fireside of the sheet about 1/16 of an inch. This will leave your copper back far enough so that when the flue is expanded and beaded down the copper ferrule will not interfere with your weld. Set your flues in the usual manner, leaving the small flues extend through the back flue sheet about 3/16 of an inch and the superheater flues ¼ of an inch.

The boiler is then given the regular hydrostatic test and all leaking flues tightened for if your flues are not tight in the sheet before welding, they will not be after. Keep oil and grease off the flue bead and sheet. Now sand blast your flues and sheet clean of all dirt and scale, bead down your flues tight against the sheet, or your

Fig. 15

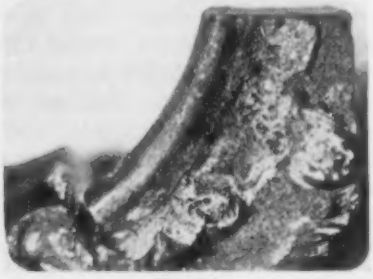

Fig. 16

beads will burn off in welding, fill your boilers with water and you are ready to weld.

Start at the top of the sheet and progress downward, starting each flue at the bottom, progressing first up one side, then the other, meeting at the top of the flue. Weld first to your flue sheet out from the flue bead the thickness of your welding wire or 5/32 of an inch, then by a weaving movement weld to the crown of your flue, bead back and forth until you have completed the flue. This will give you a strong weld on the sheet and enough metal on the flue beads to protect them.

Fig. 13 shows you a 2-inch flue, welded with ⅛ inch electrodes, using 140 amperes and 21 volts across the arc. In this case the copper ferrule was properly set so as not to interfere with the welding. The flue beaded down tight against the sheet. No oil or grease was used on the flue sheet and the sheet was cleaned with the sand blast. The boiler was then filled with water and welded. This

flue was then sawed horizontally and the strip of flue bent back and forth and finally broken off by a hand hammer and chisel. Notice how smooth and uniform the weld is applied in this case.

Fig. (No. 14) welded under the same conditions as the previous flue, excepting no water was used in the boiler. There was no oil or grease on the sheet or flue and copper ferrule so placed as not to enter into the weld. Note the clean metal shown when this flue was broken down and the perfect penetration and fusion of the weld. These two flues were each welded by a different operator.

Fig. (No. 15) shows a flue that had been set just the same as the preceding two (no oil or grease used, sand blasted clean, copper ferrule placed as in the other two). The amperage, however, was 170 with the voltage across the arc at about 26. When this flue was sawed horizontally and bent back the whole weld popped off the sheet.

You can readily see by the pocked and cinder appearance just what took place in this case. The welder operator who did this work also welded the first flue shown above.

Fig. 16 shows a result quite different from the preceding slides, and shows very convincingly the necessity of cleanliness and proper preparation. In this flue the copper ferrule was placed in the sheet and allowed to come flush on the firebox side with the result that when the ferrule was rolled tight and the flue set and beaded down the copper protruded out under the bead. Oil was used freely on sheet and flue bead. You can readily see how this copper ferrule extended out under the flue bead and how it was burned out by the metallic electrode.

Note the porous and slag like appearance of the metal. This condition is caused by the burning of the copper and oil by the steel electrode, which forms a copper monoxide gas. This gas being densest at its source, which is the flue bead and sheet prevents the molten metal from the electrode from properly fusing with the parent metal, and the entrapped vapors in liberating itself forms the slag like porous structure that you see.

Fig. 17 shows the result of the same preparation as the previous one. Note the appearance of the welded metal, also the uneven application of the metal, how it has splashed and run down. With a

Fig. 17

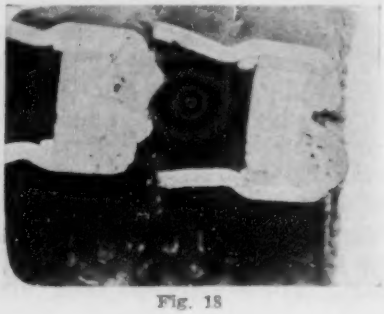

Fig. 18

clean properly prepared flue job your welder is able to apply the weld in a uniform manner, progressing rapidly and thoroughly as the metal penetrates or dives in and is readily controlled. While in an oil soaked and dirty sheet or one with the copper ferrules interfering your metal has not that snap, that clean fusion or penetration. You cannot progress with regularity as your arc is unstable and the metal backs up on the electrode and runs down on the sheet.

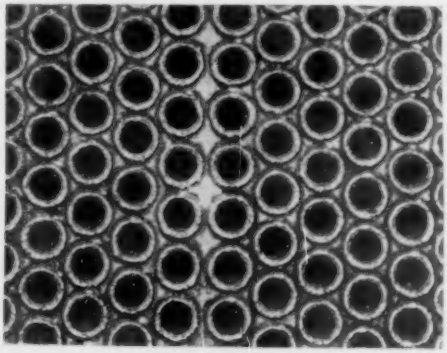

Fig. 19

Fig. 18 shows a cross section view. Notice how the copper ferrule is placed in these two flues. One placed 1/16 back from the fire side of the sheet with the result that we have perfect penetration and a clean weld. While in the other the copper ferrule was allowed to extend out under the bead with the result as you see it here, poor penetration, porous metal, and an excessive amount as in welding under these conditions, your metal backs up and runs out.

Fig. 19 gives a view of a flue sheet in which all the flues have been electrically welded. The cross denotes the center of the sheet and divides it into four parts, each welded by a different operator. Note the smooth and uniform welds.

In welding in flues with the metallic arc process the cost per flue is as follows:

Electric energy	$.017
Labor at 78c. per hour	.025
Metallic electrode material	.009
Total cost per flue	$.051

In closing let me urge that we all, welding engineers, supervisors, and welder operators, do our utmost and be ever alert to eliminate the abuses that are liable to occur in electric arc welding; for the more perfect our results the greater the demand for our work. We know that no other method of new or repair work, within its limitations can be done as economically as by electric arc welding.

THE IMPORTANCE OF MANAGERIAL UNDERSTANDING OF WELDING*

G. O. CARTER †

A long study of welding problems all over the country indicates that the advantages of welding are appreciated but that it is not used to anything like the extent that it should be.

Naturally this is because those in position to specify welding do not do so, and it is up to us to get them to do it.

The first step toward converting those who should be using the process would seem to be the supplying of information as to where welding has been of advantage in similar lines. This is necessary to give the background of experience to those who do not like to depend on personal judgment.

The second step is to convince potential users that welding as represented by trustworthy advocates of the process is dependable.

Good welds make broken castings better than when they were new. Also, a better joint between two pieces of rolled steel can be made by welding than by any other means.

One of the most difficult problems in engineering has been successfully solved by welding pipe end to end. Where oil and natural gas pipe lines cross rivers which are subject to freshlets it has been almost impossible to keep the screw joint pipes from pulling apart. Extra heavy pipe with specially heavy ends has been tried dozens of times. The lines have been anchored with river anchors at every joint and a great amount of "slack" has been put into the lines, but still they would be ripped out.

Under such conditions every possible method of handling the problem is sure to be tried by the operators, so, of course, welding has been tried. And the oxy-acetylene welded joints have given wonderful satisfaction.

Recently constructed pipe lines across the Red River, Canadian River, Brazos River, and other streams in Kansas, Oklahoma and Texas, were made by welding, and most of the old ones have been relaid with welded joints.

In West Virginia and Ohio the crossings of the Ohio, the Kanawah, the Licking and various other rivers, are oxy-acetylene welded. In short, the welded joint is in general use for a purpose where the best joint is essential.

Can any of us think of a more severe test than the carrying of seven hundred pounds pressure while a rising river is scouring out its bed and leaving the pipe unsupported for a hundred feet at a stretch with a swirling current racking the line? A straight steam line or a water line certainly doesn't meet any such severe conditions.

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*Presented at the June, 1922 meeting, Philadelphia Section, A. W. S.

†Consulting Engineer, Linde Air Products Co.

Expense isn't a consideration here, but it is a fact that the welded joint is the cheapest joint known, and is only a fifth as expensive as the Van Stone flanged joint. It would, therefore, seem that the welded joint should be in much more general use, and it will be.

Probably the greatest deterrent to welding of steam pipes has been the difficulty of inspection to assure good welding. This phase of things has been under study of a committee of the A. S. M. E. for several years. The opinion of welding students, of purchasers of welded installations, and of the fabricators, is that a combination of water pressure and an impact from a hammer or sledge will thoroughly try out welded joints.

When one who is using a 300-pound steam line knows that the line was tested at 1,000 pounds cold water pressure, and that every joint was repeatedly hammered, he is not going to worry about that line, nor should he ever have trouble with it. Many years of this kind of testing have shown it to be unqualifiedly satisfactory.

The engineer of a company that was considering putting in a large pipe line recently asked for data as to where companies which had welded one pipe line followed it up by welding others. Inquiry brought out that one of the oldest pipe welding jobs in the United States is a line from Philadelphia to Chester. This was put in during 1910, which dates it back to within three years of the beginning of the oxy-acetylene welding industry.

The important thing for us is not that this 1910 line was welded into place, but that the same company about a year ago welded a big suburban line from Philadelphia to Norristown.

On the West Coast the Pacific Gas & Electric Co., with a system of over 3000 miles of pipe line, started welding in 1913, putting in a very extensive system to serve the Panama Pacific Exposition grounds at San Francisco. Welding has been used steadily since then, and we have recently learned that at least 100,000 ft. of 16-in. pipe will be welded together this year.

Philadelphia has seen other interesting pipe welding jobs. Within the past year a big steam main was welded right along one of the principal streets, so the process may be said to be right at our elbow.

So much for the quality of welding situation.

The next problem is for us to convince prospective users that welding as done by a given welding firm is right.

Every one of us knows that welded work has often failed, due to poor welding or lack of mechanical knowledge on the part of the welder. This being common knowledge, each welding firm has to convince those interested in welding possibilities that good work will be done.

It seems to me that we should be giving our attention to this phase of our industry quite as much as to technical problems, such for example as determining the strength of a test bar, or devising the best ways of doing a given difficult job.

If each manager of welders used check methods to prove the

workmanship of his welders, insisted on preheating and annealing as a part of the welding of castings, provided only the best filling materials, and used severe tests on all finished work, the industry would command the respect of all users.

This kind of thing costs money, and the user of welding must be educated to pay for the right kind of service. There are concerns in Philadelphia, and in most big centers, which do all that is needed to uphold welding, but they do not let their fellow town's man know what they are doing. It is up to them to prove that welding as they do it is the real thing.

MATCHING THE WIRE WITH THE WORK

E. WANAMAKER*

Many tests tend to confirm what has been the general belief that the metal passing from the end of the electrode into the weld is in a highly molten state, with a generous proportion of it in a gaseous state and, therefore, extremely susceptible to atmospheric effects, even though the time of exposure to the atmosphere in this state be of short duration. By the use of such coated electrodes as are used on the Rock Island Lines (and which it might be well to say, were only developed after years of experience and patient research, laboratory and service tests), we were able, to a large degree, to greatly minimize this damaging effect. By such protection of the metal in fusion, not only has it been possible to protect the iron and low carbon steel materials, but to go further and protect many of the various alloys, the use of which is extremely desirable to meet certain conditions, such alloys as nickel, vanadium, managanese and others.

Electrodes to have any real value must be very carefully produced to meet the necessarily exacting specifications which in turn were only possible as a result of the combined prolonged efforts of those engaged in scientific research, development and application.

To produce such electrodes some expense is incurred over and above the production of mere wire, but in this and in no other way is it possible to produce an electrode of the proper composition and with the proper welding characteristics to meet the various requirements. A comparison of high-grade electrode costs with cost per pound of high grade steel castings, etc. (long ago deemed necessary) causes one to marvel at the low cost of good electrode material. It would seem reasonable to believe that we could no more secure good electric arc welds with poor or unsuitable welding material than we could expect to build machinery or structures out or poor or unsuitable material.

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*Electrical Engineer, Chicago, Rock Island & Pacific Railroad.

The necessity for welding materials of different composition to make possible productions of welds of various characteristics as desired to meet the service requirements, has been recognized for some time in oxy-acetylene welding. Yet there are many users of electric arc welding who endeavor to apply welding to different metals, each of a different analysis, using only one grade of electrode material. This should not be construed to mean that the composition of the welding electrode should in all cases be the same as the base metal. As stated above, the service requirements will determine the character of the weld metal desired.

For example, cast iron electrodes have recently been used to build up worn chafing cast steel castings between engine and tender of locomotive. The cast iron was simply deposited on the steel casting and allowed to cool normally, the rate of cooling being sufficiently quick to effect the formation of white cast iron, which is extremely hard, but especially suited for the service mentioned.

Examples of welding applications where the use of an electrode of an analysis or character approximately that of the base material has been found desirable or necessary to the success of the operation, are those of welding vanadium steel locomotive frames, where vanadium steel electrode material is used; or in the case of building up worn steel car wheel flanges where the wheel was slightly preheated and the flange built up with a high carbon steel material. In each case the weld metal is of similar character to the part welded, and likewise the service obtained is similar to that of the original part.

The desirability of electrode materials to better facilitate electric arc welding of the different metals and to meet the diversified service requirement in repair and construction work, is recognized by many, but the fact remains that the use of such materials is not generally practiced and in many cases where their use would have done much to give electric arc welding the standing to which the process is entitled.

To the Welding Industry:

We are submitting herewith a report from the Resistance Welding Committee dealing with nomenclature of terms used in resistance welding. In the past much confusion has resulted because of the lack of such standardization, as in many cases the same terms used by different people referred to totally different things. We trust that the welding industry will accept and use these terms in order that they may become universally recognized.

We realize, however, that the first issue of any Standards or Definitions of Nomenclature is likely to be imperfect and hope that all those interested will feel free to offer any criticisms or suggestions.

C. A. ADAMS,
Director American Bureau of Welding.

NOMENCLATURE REPORT*

Electric Resistance Welding

A. *Butt Welding.*

Butt Welding is the process of uniting rods, bars, etc., transverse to the length of the pieces or its equivalent. There are three methods of producing a butt weld that are in common use.

1. *Flash Weld.* This name is given to a butt weld made quickly starting with light contact pressure followed by a period of sparking with no pressure applied, and finished with heavy pressure, and by the use of enough heat to melt a portion of the metal, part of which is thrown out in the form of a burr.
2. *Upset Weld.* This name is given to a butt weld made with only enough heat to bring the pieces to a welding temperature and executed slowly with considerable pressure producing an upset at the joint.
3. *Automatic Butt Weld.* This name is given to a butt weld made quickly, using high continuous contact pressure and heavy current, the current being cut off by movement of electrode or other means of control. Sometimes called Pressure Contact Weld.

The following terms are used to describe variations of Butt Welding:

(a) *Jump Weld.* When rods, tubes, strips, etc., of small cross-section are welded at right angles to a relatively larger surface by using a high secondary voltage, and weld is made instantaneously, the weld is called a Jump Weld.

*Prepared by the Resistance Welding Committee of the American Bureau of Welding.

(b) *T. Weld.* When flat strips, bars, etc., are welded at right angles in form of a T, the weld so made is called a T Weld. Sometimes a portion of one piece is preheated by the welding current prior to welding.

(c) *Angle Weld.* When pieces are welded at an angle, the weld is termed an Angle Weld.

B. Spot Welding.

Spot Welding is the process of welding sheets, strips, etc., in spots by bringing together and heating relatively small sections of the sheets between copper or other suitable electrode points under pressure.

Automatic Spot Weld.

This name is given to a spot weld made on a welder which applies the pressure, makes and breaks the circuit all automatically.

The following terms are used to describe different variations of Spot Welding:

1. *Lap Spot Weld.* When sheets or pieces are overlapped and spot welded, the weld is called a Lap Spot Weld.
2. *Bridge Weld.* When sheets, pieces, etc., are placed edge to edge without overlapping and then joined by spot welding discs or strips across the joint, the weld is termed a Bridge Weld. Sometimes called a Tie Weld.
3. *Button Weld.* When small buttons are used between the pieces to be welded as a means to localize the heat, the weld is termed a Button Weld.
4. *Disc Depression Weld.* When an annular groove is cut in one of the sheets forming a disc to localize the heat, the weld is called a Disc Depression Weld.
5. *Point Weld.* When points or projections are provided to localize the heat, the weld is termed a Point Weld. Also called a Projection Weld.
6. *Multiple Point Weld.* When two or more points are provided, and electrode is large enough to cover them, the weld is called a Multiple Point Weld.
7. *Multiple Electrode Weld.* When several electrode points are operated simultaneously, the weld so made is called a Multiple Electrode Weld.
8. *Ridge Weld.* When ridges are provided and weld is made by crossing these ridges, thus localizing the heat at points, the weld is termed a Ridge Weld.
9. *T Spot Weld.* When pieces are welded in form of T by holding one piece in hollow electrode and spot welding it to the other, the weld is called a T Spot Weld.
10. *Duplex Spot Weld.* When two transformers are used simultaneously on opposite sides of the sheets to be welded

and their currents pass through two secondaries, welding two spots simultaneously, the weld is called a Duplex Spot Weld.

C. *Mash Welding.*

Mash Welding is the process of welding rods, wires, strips, etc., by crossing or overlapping the pieces and welding between relatively large electrode surfaces under pressure.

D. *Seam Welding.*

Seam Welding is the process of joining together metal sheets or plates in a continuous seam or line, the weld being accomplished continuously or progressively.

Seam Welding may be of the following types:

1. *Butt Seam Weld.* When the pieces meet edge to edge and are progressively butt welded, the weld is termed a Butt Seam Weld. Usually two rollers of copper supply the current.
2. *Lap Seam Weld.* When the seam weld is made in the form of a lap joint, the weld is called a Lap Seam Weld. Current may be supplied by two rollers or one roller and one stationary contact.
3. *Bridge Seam Weld.* When edges are butted together and a strip or sheet is welded over this joint, the weld is called a Bridge Seam Weld.

D. *Percussive Welding.*

Electropercussive welding is a process of welding electrically separated metal parts by means of a sudden discharge of electrical energy at the junction in an arc which is extinguished by a percussive blow applied simultaneously or immediately following.

1. *Electrostatic Weld.*
   When the discharge of a condenser is used to supply the arc energy the weld is termed an electrostatic weld.
2. *Electromagnetic Weld.*
   When the stored energy in a magnetic field is transformed to electrical energy by collapse of the field to supply the arc energy, the weld is termed an Electromagnetic Weld.

Respectfully submitted,

*H. LEMP, Chairman Resistance Welding Committee.
*M. THOMSON, Chairman, Sub-Committee on Nomenclature.
C. W. Bates,
E. F. Collins,
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PRESENT STATE OF THE ART OF RESISTANCE WELDING

There is given below the first of a series of papers that are being prepared under the auspices of the Resistance Welding Committee of the American Bureau of Welding to set forth the present state of the art and knowledge of resistance welding. This summary will serve the two-fold purpose of giving the industry a concise statement of the best existing information and enabling the committee to draw up a careful program of needed research.

Review of Electro-Percussive Welding*

D. F. MINER

Definition

Electropercussive welding is a process of welding in which the heating energy is applied at an extremely rapid rate simultaneously with or followed by a percussive forge of the molten surfaces. The process owes its properties to the unusually high rate of energy dissipation and the forging operation following in a small fraction of a second.

History

The principles of electropercussive welding were discovered by L. M. Chubb of the Westinghouse Electric and Manufacturing Company, about 1905 during some experiments with aluminum trays for electrolytic lightning arresters. It was found that if two wires connected to a charged condenser were rapidly brought together, they would be fused at first contact. The momentum would cause the molten ends to weld and produce a burr or upset portion. These experiments led to investigation of the characteristics of such welds with various materials. The properties found were so remarkable that machines were soon developed for welding wires for special applications, such as leads for incandescent lamps and rectifier bulbs, and for welding copper terminals to aluminum coils and manufacture of thermocouples. With these early machines, very satisfactory welds were made between similar or unlike metals. These welds developed full strength of the material, permitting rolling or drawing without failure. Combinations of metals with widely differing physical characteristics such as platinum to lead, tungsten to aluminum, and aluminum to copper were successful. Microphotographic study of such welds confirmed the mechanical tests. Within the last few years, as a result of limitations of the electrostatic energy scheme, modifications of the process were introduced using stored electromagnetic energy. This change enlarged the field of application considerably and removed the limitation of dimensions of welded area. Recently other sources of energy such as a storage battery and generator with great inertia have been successfully used. The proper field of ap-

*In view of the fact that the Westinghouse Electric & Mfg. Co. is the only concern which is selling this type of equipment, this report is presented as a paper by Mr. D. F. Miner of that company, rather than as a report of the Resistance Welding Committee.

plication for the various types of energy supply used is now under investigation.

Characteristics and Advantages

Percussive welding possesses features which relate to arc welding, and to resistance welding of the butt type. Although the heat occurs in an arc between parts to be welded, probably the most satisfactory classification is under Resistance Welding. In arc welding the joint is formed by deposition of molten metal from an external supply, whereas in resistance welding, material from the parts to be welded becomes molten by passage of current and joins the two parts together.

With respect to nature of objects capable of being electro-percussively welded, the process will probably be limited to joining the parts which are not electrically connected before welding. Welding of a ring or object which offers an electric path parallel to the weld presents difficulties which are not practicable to overcome at present. The weld should be the only path possible for the discharged energy.

Some of the advantages claimed as characteristic of electro-percussive welding are:

(a) *Energy Saved.* As compared with butt-welding by ordinary means, the energy used in percussive welding is at the most only one quarter as great. In production of large pieces in quantity this amount translated into generating equipment and losses represents a great saving.

(b) *Time Saved.* The time occupied by the cycle of welding operations is negligible. Speed of production is then determined chiefly by methods of handling pieces. Automatic and semi-automatic devices in connection with the process permit a very great speed of production.

(c) *Welds of Unequal Sections.* The extremely short duration of the fusing arc in the percussive process allows no chance for the heat to travel back into the metal. The necessary energy is concentrated in a very small amount of material, utilized where needed, and not dissipated in heating up the rest of the stock. Consequently welds of unequal section are possible, such as a rod of small cross-section to a heavy plate or tubing to solid stock. No preparation of the surfaces or previous treatment is necessary. Preheating of the larger section or special forming of projections is eliminated.

(d) *Welds of Unlike Metals.* A wide variety of combinations of metals or the same metal in different states can be welded satisfactorily. Welds which are impossible for any other process are successfully accomplished by percussive welding. Because of the short time of welding, change of state of metals is avoided. Temper of the body of steel tools is retained and crystal growth in ferrous materials does not have time to take place.

(e) *Uniformity.* The energy discharge is determined by the setting of the machine and circuits. Thereafter a remarkable uni-

formity of product is assured with relatively unskilled labor. Judgment as to temperature, time or pressure needs to be exercised only for the first set-up.

(f) *Finishing.* The fin or burr can be controlled and in all cases is less than with other processes so that finishing time and labor are reduced.

Classes of Machines

A. Condenser Type of Welder.

The earlier machines developed utilized the discharge of an electrolytic condenser to fuse the wires. A diagrammatic arrangement of the circuits is shown in Figure 1. Direct current from a suitable source, such as a small generator was applied through a charging and limiting resistance R, to the condenser C. The charge was varied by voltage control.

The discharge circuit of the condenser consisted of a low reactance L, the wires to be welded and a short-circuiting switch. The chucks for holding the pieces were arranged in a vertical position so as to allow the upper one, held in a weighted head to fall, actuated by gravity, to produce the percussive action. The wires were prepared with sharpened ends to concentrate the energy and

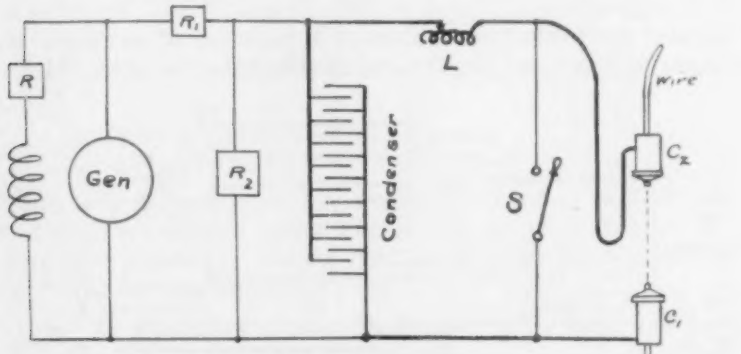


Fig 1

CONDENSER TYPE WELDER

promote rapid fusion. As the head continued to fall, these points melted and spread out.

The variable elements of the apparatus were height from which weighted head dropped, voltage on condenser and delaying reactance. Hard metals require more forging energy and usually more heat energy. The latter was furnished by raising the condenser voltage. As the rate of impact is increased, the delaying reactance must be decreased to allow quicker fusion.

Since the earlier models, improvements were designed to obtain more convenient chucking arrangements, reduction in bulk of the

electrolytic condenser, and substitution of springs for gravity actuation.

Electromagnetic Type

The electrostatic method is limited in size to pieces coming under the classification of wire. For large cross-section the electromagnetic type is more suitable. Practically simultaneous discharge of electrical energy and percussive engagement are also used in this later type of machine but stored electro-magnetic energy is substituted for electrostatic energy.

Establishment of a strong direct-current field in a reactance coil with a primary and secondary winding is followed by rupture of the primary current with the secondary circuit closed. Transfer of energy of the collapsing field to the secondary ensues and a subsequent rapid separation of electrodes (the pieces to be welded) in this circuit establishes an intense arc until the stored energy is dissipated. After the arc has sufficiently melted the surfaces, a forging blow unites the pieces.

The total time consumed in these operations is less than 1/10 second. The mechanism to provide this sequence of events can be designed to suit the source of power or conditions of manufacture. Mechanical or electrical timing both have been used. Figure 2 gives a diagrammatic sketch of the circuits of one of the first experimental machines and because of separation of parts for study and control, is a good illustration of the main features. Here the

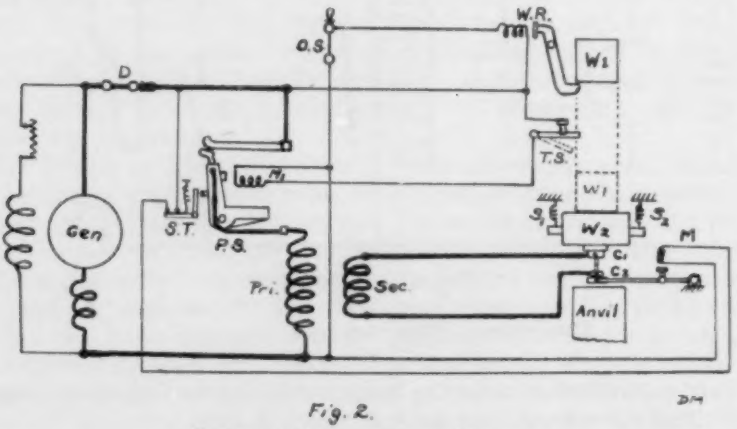


Fig. 2.

ELECTROMAGNETIC TYPE WELDER

forging device is represented as a falling hammer. Spring, air, and electrically operated hammers have since been used.

A cycle of operations for this experimental machine is as follows:

The primary is energized by closing switch D which also causes lower electrode C_2 to be raised by magnet M. Then operating switch O. S. is opened and magnet W.R. de-energized. The hammer falls and in its travel trips switch T. S. This releases primary

switch P. S., kicking out trip S. T., which then opens the secondary circuit at the weld. An arc is thereby established and extinguished when the hammer completes its travel with the forging blow. The electrical phenomena are illustrated by Figure 3.

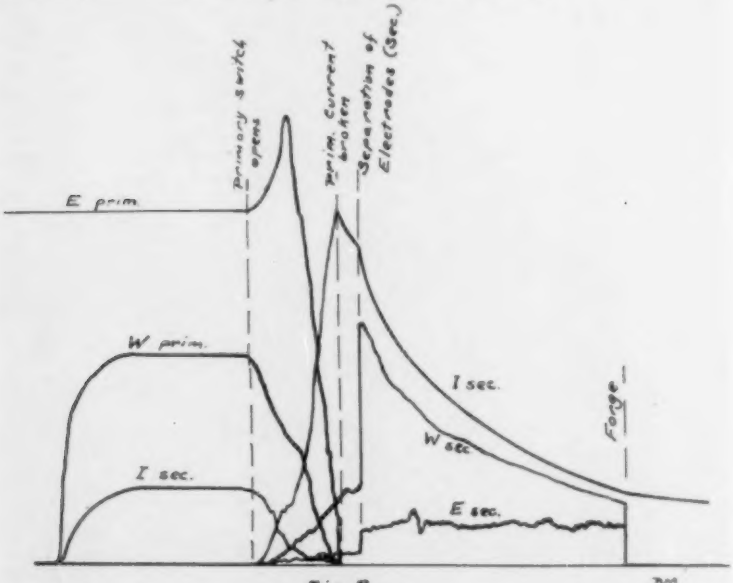


Fig. 8.

OSCILLOGRAPHIC DIAGRAM
ELECTRO-PERCUSSIVE WELD

A specially designed primary switch is necessary to interrupt the circuit without energy being lost at the switch. The control to perform the necessary timing operations involves a combination of electrical and mechanical devices.

Examples of Electropercussive Welding

Index to Figures 4, 5, 6, 7.

1. Aluminum cable joint. Each wire of each end welded to a copper wire and the copper wires then joined by standard method of soldered joint.

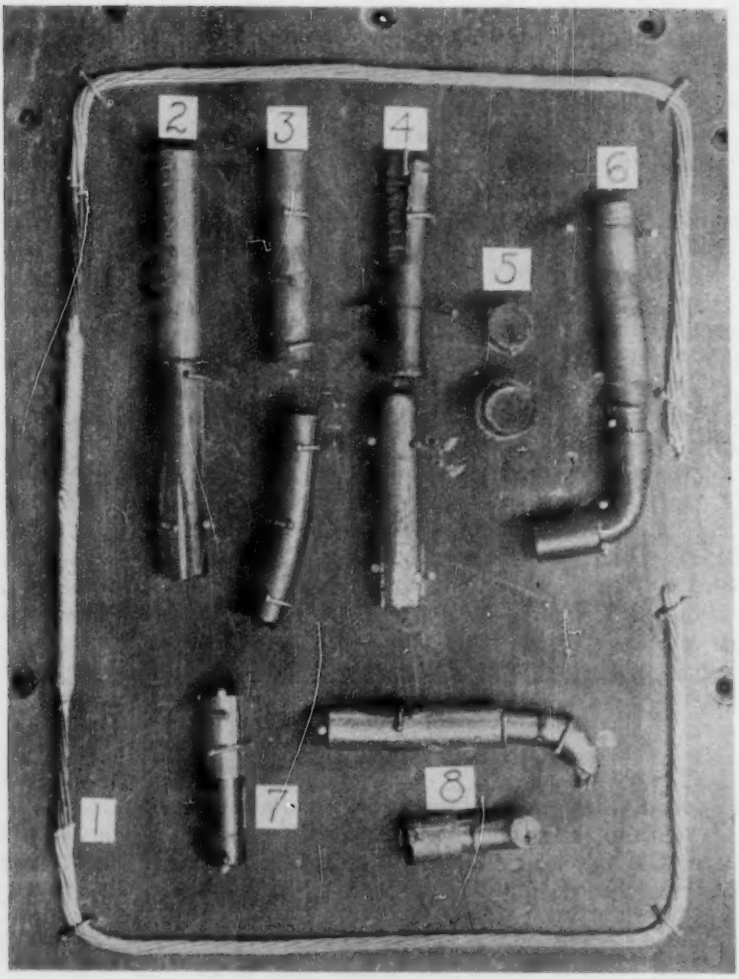
2. Steel (cold rolled ½ in.) welded to ½ in. copper and pulled until chuck gauged metal—load applied, 41,000 lb. per sq. in.

3. ½ in. steel welded to ½ in. copper. Broken by bending copper. Break is a copper break—no steel shows.

4. ½ in. steel welded to ½ in. copper. Failed in tension at load of 37,600 lb. per sq. in. Broke in copper near weld.

5. ½ in. steel welded to ½ in. copper showing character of break of copper.

6. ½ in. steel turned down to ⅜ in. and welded to ½ in. copper rod similarly turned down. 1 in. from weld another section of cop-



per turned down to 3/8 in. and wrench applied to end. Copper bent without weld failing.

7. 7/16 in. steel-copper weld polished showing clean line of weld.

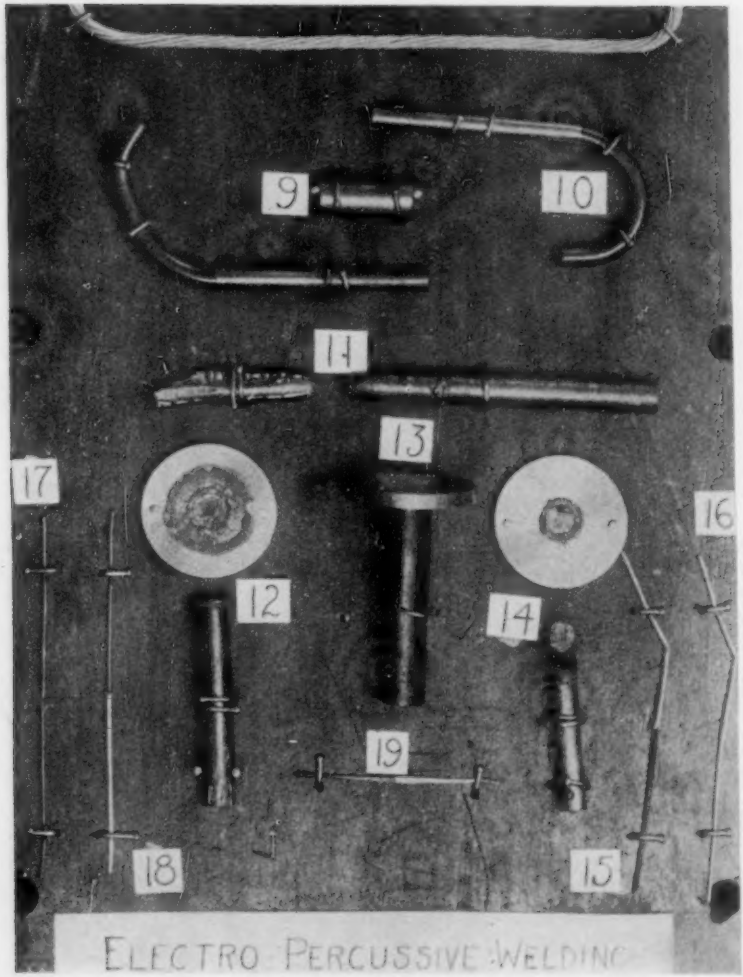
8. 3/8 in. steel—steel weld bent and hammered in all directions all along reduced section until steel broke 1¼ in. from weld.

9. Double weld-steel ½ in. to copper ½ in. then cut off and re-welded to another copper rod.

10. ¼ in. copper to steel. Bent without failing.

11. 3/8 in. steel (cold rolled) weld pulled to failure. Steel necked and failed 1 in. from weld at 96,000 lb. per sq. in.

12. Brass rod 5/16 in. to steel disk 1½ in. diameter, 5/32 in. thick. Failed in tension, pulling out steel from disk.



13. ½ in. copper rod welded to 1½ in. by 5/32 in. steel disk.

14. 5/16 in. steel rod welded to 1½ in. by 5/32 in. steel disk. Broken by bending. Force applied at middle of rod. In failing, pulled metal out of disk.

15. Steel wire welded to aluminum wire.

16. Aluminum-aluminum wire weld.

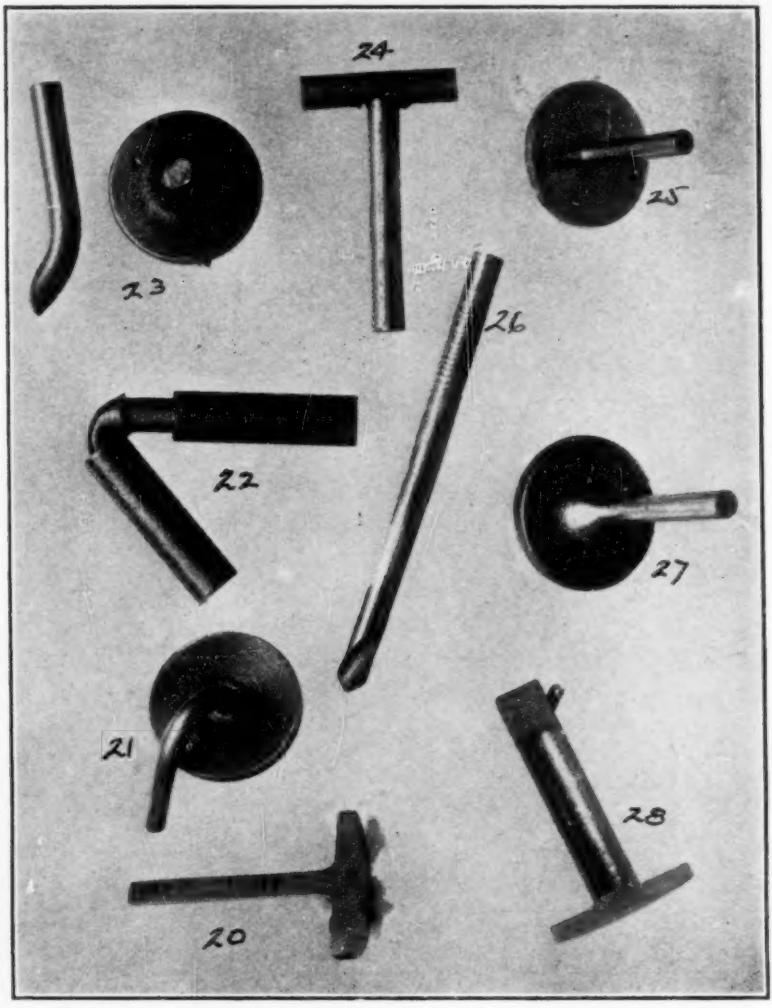
17. Steel-copper wire weld.

18. Copper-aluminum wire weld.

19. Copper-aluminum wire weld flattened by hammering.

20. ¼ in. copper rod welded to steel disk. Penetration of metal and clean line of weld shown.

21. ¼ in. steel rod welded to steel disk and tested in bending without failure.



22. Weld between two sections of copper 5/16 in. diameter. Bent at sharp angle so that copper outside weld is cracked.

23. Valve with nickel steel head and cold rolled steel stem bent to failure which occurred outside weld. Note unchanged structure of steel close to weld.

24. T-weld of cold rolled steel.

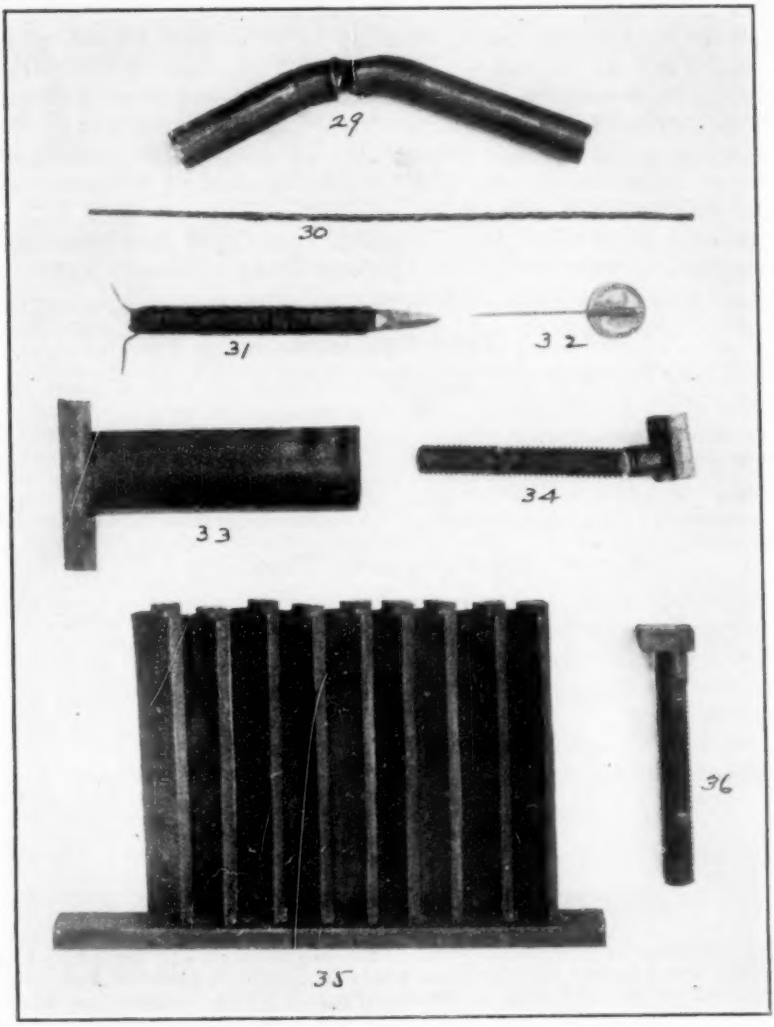
25. Cold rolled steel rod welded to disk and finished.

26. Short drill lengthened by welding to cold rolled steel.

27. Nickel steel valve head with C. R. S. stem.

28. ½ in. hollow steel rod welded to steel plate.

29. ½ in. x ¼ in. steel tubing welded and bent back and forth until failure occurred outside of weld.



30. Vacuum tube lead-in of stranded copper to tungsten.
31. Special copper-constantan thermocouple made of round wire (No. 24) bent into loop and rolled to .001 in. thickness.
32. Stick-pin (dime to gold pin).
33. Illustration of turbine blade (bronze) to steel block.
34, 36. Switch stud blank (copper).
35. Section of turbine blading.

Applications

The electro-percussive process is still under development. Improvements in design of the component parts and study of proper applications for different types are being made.

The process is primarily suited to manufacturing applications,

where large quantities of duplicate parts are to be produced. The initial outlay for equipment is rather large so that a good volume of production is necessary. One size of machine will handle a variety of pieces over quite a range of size, but special fixtures must be provided for each piece. Thus it will be apparent that repair work or occasional use would not justify the investment. There is unlimited opportunity for development of automatic machines utilizing this process.

The field of application of the different types developed up to the present, as determined by experimental and manufacturing experience may be outlined as follows:

Condenser Type

Small wire products.
Laboratory products.
Thermocouples, etc.
Jewelry.
Small tools and instruments.
Vacuum type and lamp parts.

Electromagnetic Type

Automobile parts in large number.
Tool manufacture and reclamation.
Hardware and cutlery.
Turbine blading.
Rail bonds.
Switches and electrical detail supplies.
Tubing joints.

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Technical Bulletins

These Bulletins are published under the auspices of the American Bureau of Welding. The Bureau is a joint advisory board of the American Welding Society and the Division of Engineering of the National Research Council on welding research and standardization. It acts as the Research Department of the Society.

BULLETIN No. I

Standards for Testing Welds

These Standard Tests Comprise

(a) Shop Standard: A simple standard test for such purposes as checking the work of a welder, testing a new lot of welding wire, and testing the effect of some change in conditions.

(b) Commercial Standard: For cases where more than one kind of test should be made but where the circumstances do not justify a complete investigation.

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Price per copy—Members 25 cents, Non-members, 50 cents.

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Welding Wire Specifications and Folios

The specifications and folios are based on the data collected by the Welding Wire Specifications Committee as to the chemical analysis of welding wire used for both gas and electric welding in railroads, shipyards and other places and the service results obtained from the use of such wire.

Price per copy—Members 25 cents, Non-members 50 cents.

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Standards for Electric Arc Welding Apparatus

These rules provide Standards for use in connection with specifications for the purchase, sale and use of Arc Welding Apparatus. The rules include classification, definition of terms, information relative to apparatus to be supplied by the prospective supplier and by the prospective purchaser, respectively, and tests. Price per copy: Members, 15c; Non-Members, 30c.

The American Welding Society

The American Welding Society is organized to provide united and co-operative action in extending the knowledge of the art of welding and its field of industrial application. The field for further application of welding is enormous, and progress in it is being delayed only by incomplete knowledge and by the confusing and opposing claims of competing interests.

The Society acts as a clearing house for information. Through papers and monthly meetings of local sections of the Society an opportunity is created for the individual manufacturer, engineer, plant superintendent, foreman, operator, etc., to contribute his own knowledge in welding and at the same time receive the benefit of the combined knowledge and experience of all other members of the Society. Special publications in addition to the regular monthly proceedings are issued from time to time giving results of researches, standardization work and other information of value to the members.

CLASSES OF MEMBERSHIP
Extracts From By-Laws

ARTICLE I.

Section 1. Individuals having received the approval of a majority of the Membership Committee shall become members of this Society upon the payment of dues, except in the case of honorary members who shall be elected by unanimous vote of the full Board of Directors.

Section 2. Membership shall be divided into five classes:

Class A. Sustaining members, being individuals or individuals delegated by corporations, firms, partnerships, etc., interested in the science and art of welding, with full rights of membership.

Annual dues $100.00

Class B. Members, being individuals interested in the science and art of welding, with full rights of membership.

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Class C. Associate members with right to vote but *not* to hold office, except in Sections as may be provided for by the By-Laws of the Sections. Supervising welders, inspectors and skilled operators, with three or more years' practical experience in welding are also eligible to this class.

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Class D. Operating members, who are welders or cutters by occupation, without the right to vote or hold office except in Sections as may be provided for by the By-Laws of the Sections.

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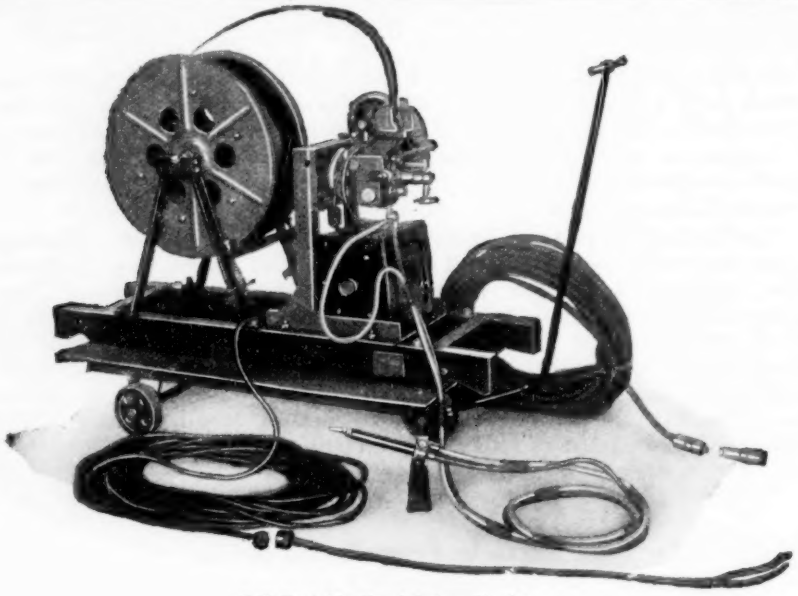

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